AGENCE NATIONALE DE LA RECHERCHE ANR

ISARD

INTENSIFICATION ÉCOLOGIQUE DES SYSTÈMES DE PRODUCTION AGRICOLES PAR LE RECYCLAGE DES DÉCHETS

Urban and livestock wastes in the tropics:

characterization and modeling of their transformations in soil to better choose their potential utilization

La Réunion Island

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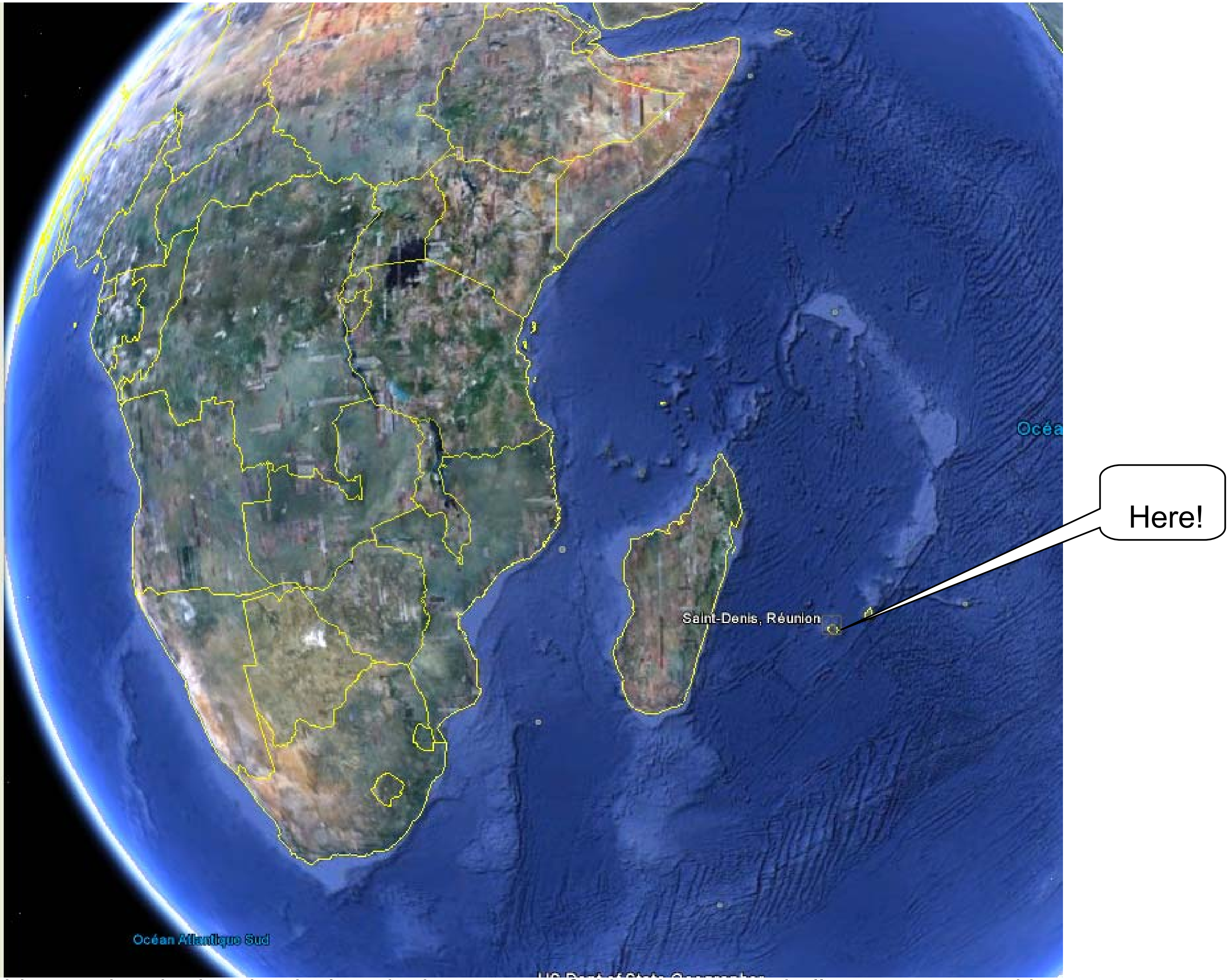
LA RECHERCHE AGRONOMIQUE POUR LE DÉVELOPPEMENT

La Réunion?



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La Réunion: lagoon, volcano..

OK, but also…


Vinasses (rhum) spreading


Liquid manure spreading
Pict. PF Chaballier


Manure… overflow

The situation (1/2)

- Increasing production of organic « wastes »

- Various organic materials (OM) from different origins
  - traditional (agri-food industry)
  - new or emerging (urban)

- Uses?
  - Soil inputs
    - Product status: organic amendments & fertilizers
    - Waste status: with legal constraints
    - Where?
      - (trad) needs for market gardening (high), pastures
      - (new) needs for sugar cane (increasing price for inorganic fertilizers)
  - Other
    - Landfills
    - Energy

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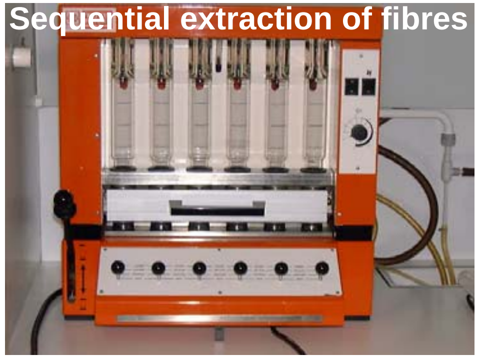
The situation (2/2)

- Characterizing of an OM by lab methods is generally:
  - **Expensive** (ex. potential nitrogen transformation: 2000 €)
  - **Time consuming** (ex. plant fibres: 1 week; pot N transf. : 6 months)
  - **Not environmentally friendly** (utilization of solvents, chemicals)



- Lack of references on ‘new’ OM in terms of their C & N transformations (models)
- Lack of knowledge: less rationality for their utilizations

Questions

- Is it possible to develop some new tools for a rapid, inexpensive and environmentally friendly characterization of various OM?

- Is it possible to use this data as input in models of OM transformations (C & N)?

Objectives & Applications

Develop a method for a rapid characterization of various OM, to:

predict the transformations of the OM added to soil (modeling)

(re-)direct the production of organic fertilizers

help in decision making (return to soils, energy?)

Management of OM (organic wastes from the agriculture /town), material choice & transformation process

- Agriculture/Urban sector:
  La Réunion, Madagascar & Sénégal; environmental and sanitary hazards (trace metals) in peri-urban situations (Project ISARD)

Organic Materials (La Réunion)

- Livestock effluents
  - Raw




  - Transformed by composting

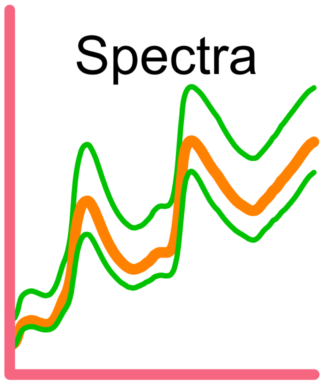


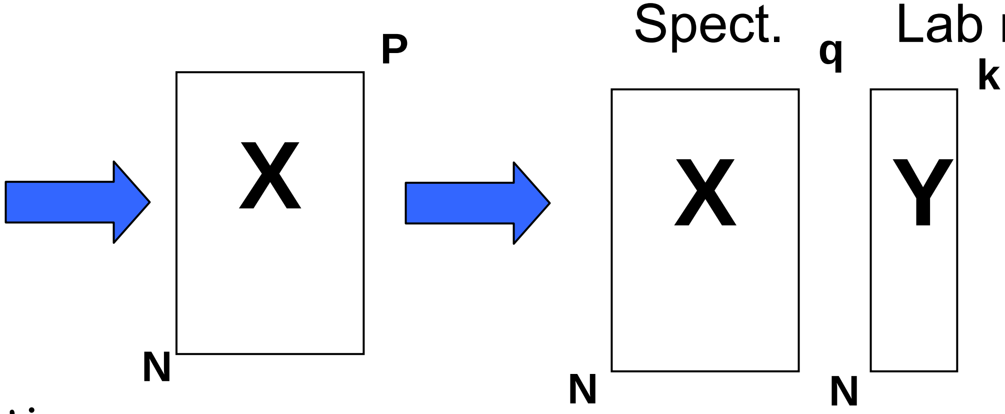
Organic Materials (La Réunion)

- Urban wastes
  - Raw
    - Green wastes
    - Sewage sludges

  - Transformed by composting (+ mixtures)

Methods: The NIRS tool, build a NIRS model?



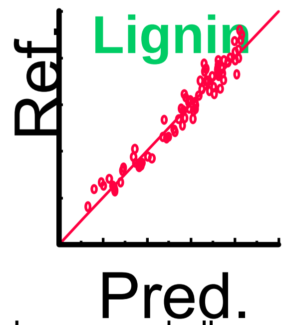


Spectra acquisition
Spectral data matrix
Control of the spectral population

Chemometry: Calibration development
regressions: MLR, PLS, neuron netw..

$$\hat{Y} = b_0 + b_1X_1 + \ldots b_iX_i + b_pX_p$$

Model validation
Database maintenance



$$SEP = \sqrt{\frac{\sum(y_i - \hat{y}_i)^2}{N}}$$

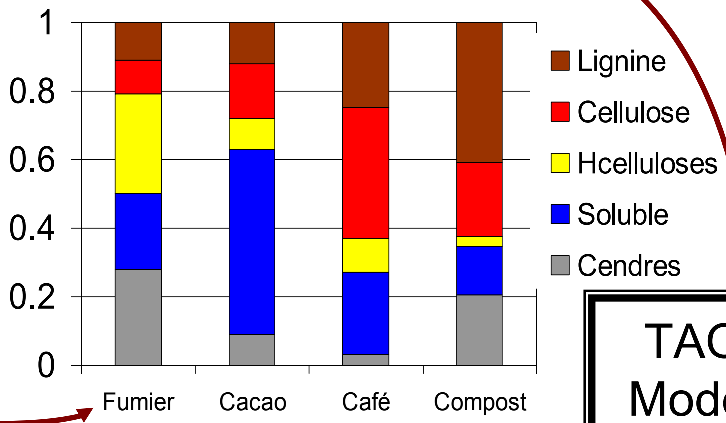
Methods: Modeling the decomposition of OM; TAO

Chemical and biochemical characteristics are used as input data for the modeling of C and N transformations of OM added to soils :

The TAO model: Transformation of Added Organics

- Functional compartments = *f*°(measurable fractions)

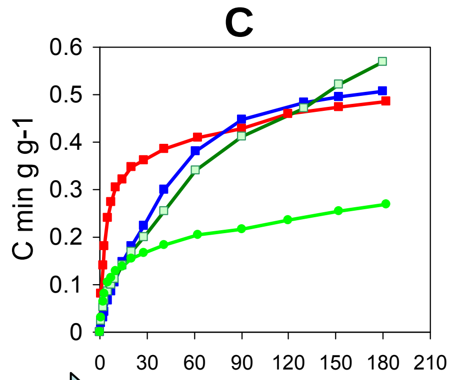
biochemistry

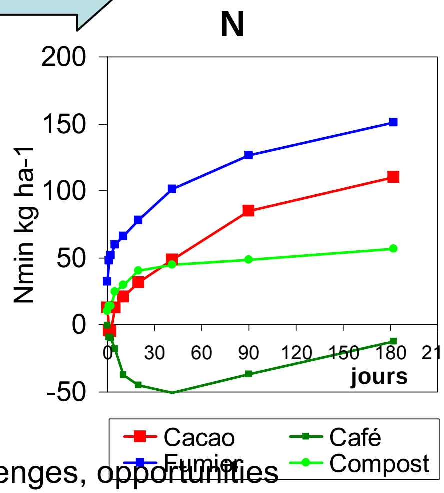


chemistry

C, N

TAO Model





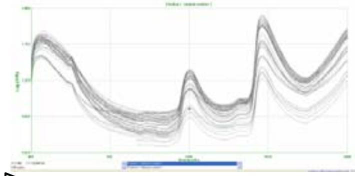
NIRS + TAO modeling

NIR predictions of some important characteristics of OM

Utilization of the TAO model and Predictions of the OM dynamics

preparation

acquisition



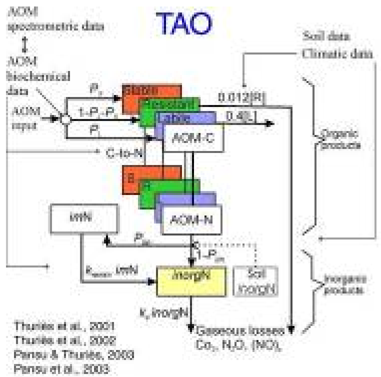
treatment

+ ref data

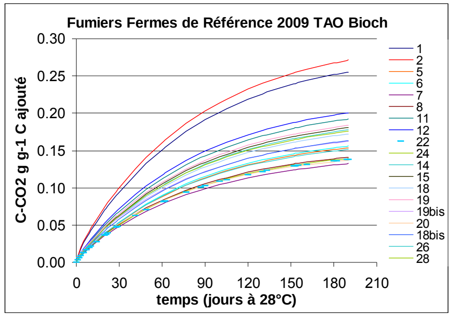
NIR modeling

SOL
HCEL
CEL
LIG
Cend
C
N

TAO modeling



prediction



C min° predictions of manures

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Results

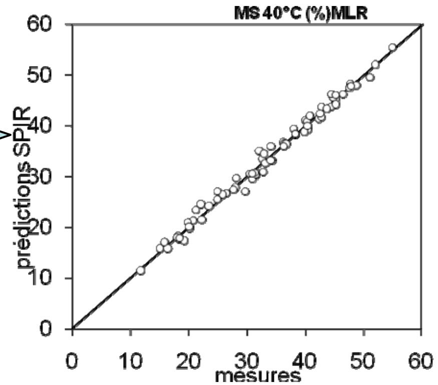
– *« Improving the characterization of effluents by means of new methods and models, for a better agronomic consideration »*

NIR characterization at a laboratory level

NIR characterization *in situ*

Portable NIR

NIR models DM, OM, N



$R^2 = 0,9875$

SECV = 1,17

RPDcv = 9,00

NIR model classified as excellent

($R^2>0.9$, RPD>3) (Saeys et al., 2005)

Urban/Agricultural sectors

– *« Organic materials from livestock or town under tropical climates: the use of Near Infrared Spectroscopy to choose their potential utilizations in agriculture and/or energy »*

Collaborations: LRI, IRD & INRA

		C:N
Sugar scum (lime)	ECUM	5
Slaughter sludge	PROCESS	8
Goat manure	FUMCAB	9
Dairy manure	FUMBOV	6
Dairy slurry	LISBOV	6
Chicken manure	LITV	10
Chicken manure	LIT Av	10
Chicken manure	LITCOUV	11
Chicken manure compost	COMREPRO	8
Chicken manure compost	CFV	11
Centrifuged pig slurry SJ	LISPc SJ	17
Compost of centrifuged pig slurry	CLPv SJ	9
Composted pig manure	CLP Co	15
Green waste compost +SS	CDVB	10
Green waste compost	CDV SP	17
Green waste compost	CDV LP	11

C & N wide range

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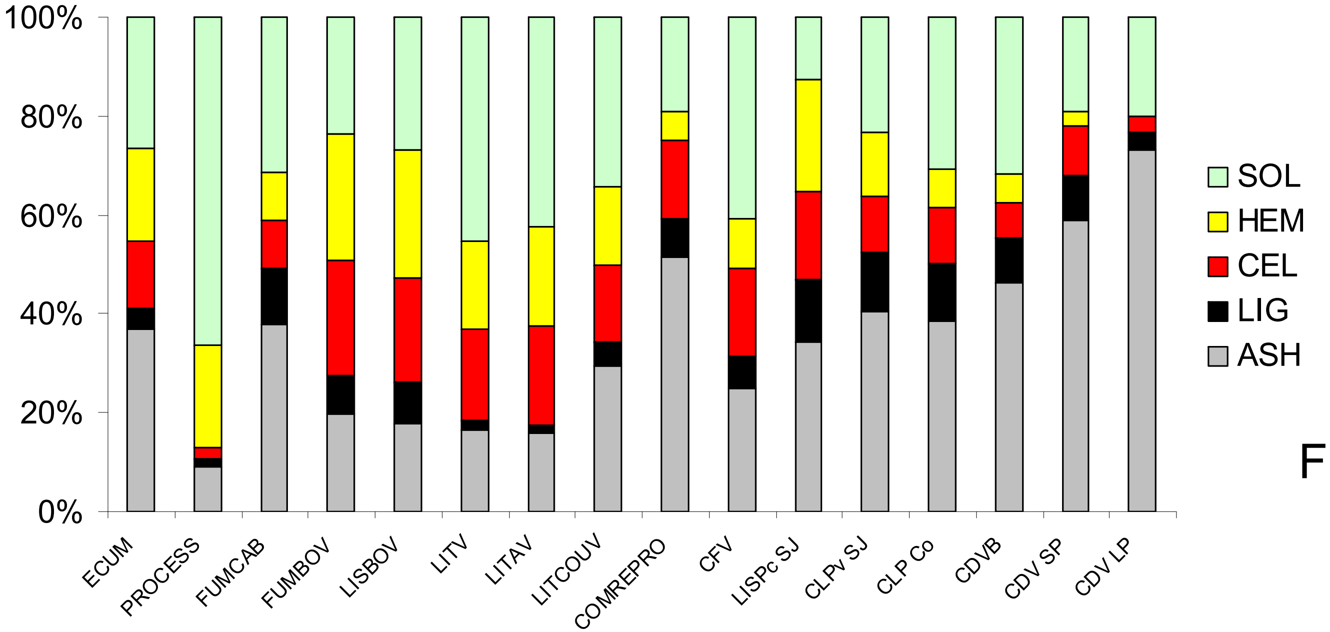
Urban/Agricultural sectors



Fibers wide range

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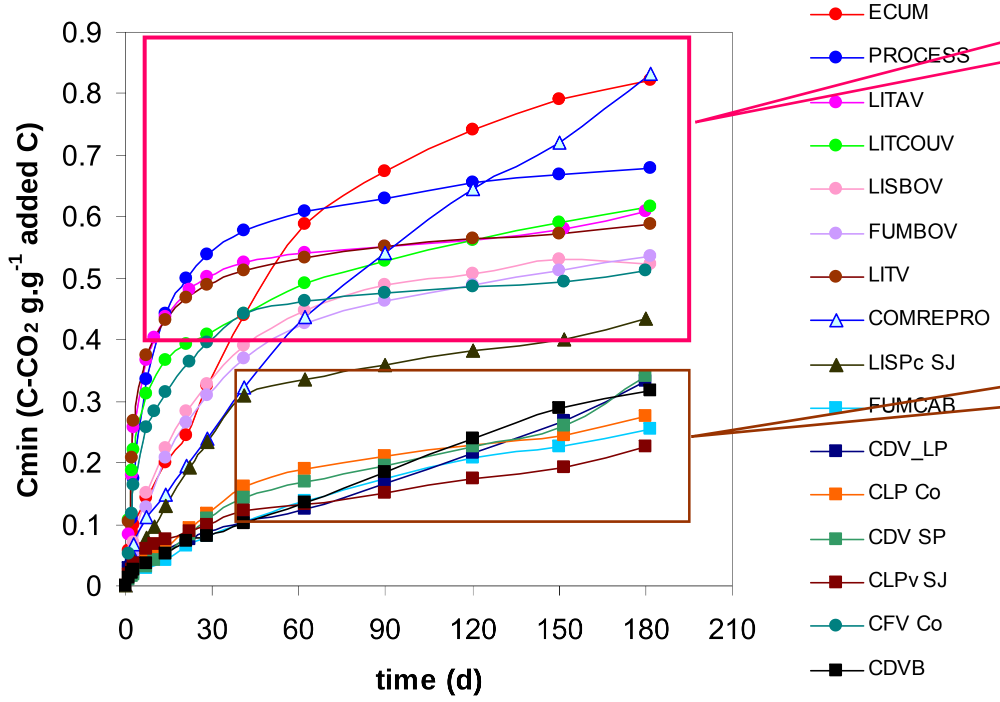
Urban/Agricultural sectors

Potential mineralization of C & N

- effluents (agricultural & agro-industrial)
- effluent composts
- green waste composts +/- sewage sludge

raw or +/- uncomposted



composts

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cirad Urban/Agricultural sectors

		TAObioch	
		PL	PS
Sugar scum (lime)	ECUM	0.20	0.15
Slaughter sludge	PROCESS	0.39	0.06
Goat manure	FUMCAB	0.22	0.41
Dairy manure	FUMBOV	0.18	0.29
Dairy slurry	LISBOV	0.20	0.31
Chicken manure	LITV	0.28	0.08
Chicken manure	LIT Av	0.26	0.07
Chicken manure	LITCOUV	0.24	0.18
Chicken manure compost	COMREPRO	0.17	0.29
Chicken manure compost	CFV	0.25	0.23
Centrifuged pig slurry SJ	LISPc SJ	0.05	0.46
Compost of centrifuged pig slurry	CLPv SJ	0.18	0.43
Composted pig manure	CLP Co	0.16	0.42
Green waste compost +SS	CDVB	0.23	0.33
Green waste compost	CDV SP	0.13	0.32
Green waste compost	CDV LP	0.26	0.13
	min	0.05	0.06
	max	0.39	0.46
	mean	0.21	0.26

Calculated with fibers + C & N

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Usefulness of NIR predictions for the TAO model

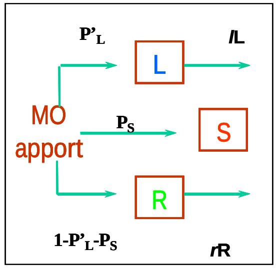
Modèle TAO : 1er ordre 3 compartiments,

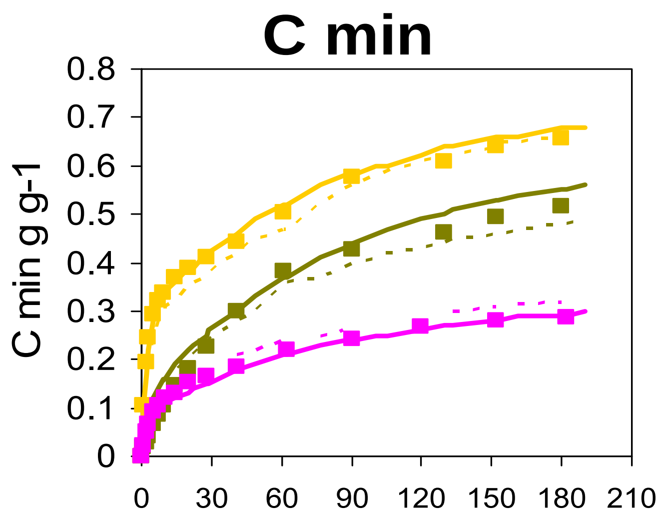
- **L**, labile
- **R**, résistant
- **S**, stable

l cte minéralisation de **L**

r cte minéralisation de **R**

TAO





P_L, P_R, P_S = *f*° (NDSoluble, Hémicelluloses, Cellulose,Lignine, MO, Nt)

Lab data or NIR predictions

The TAO model can be run with lab data or NIR predicted data

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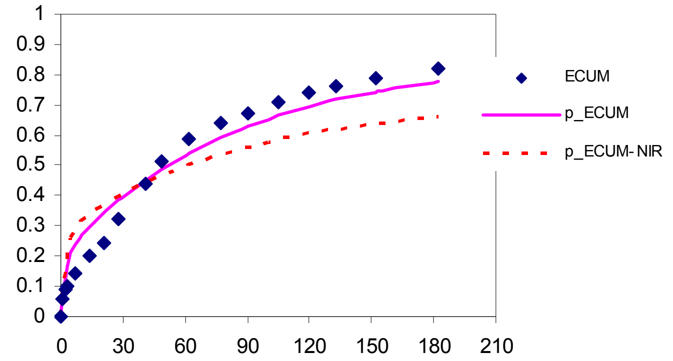
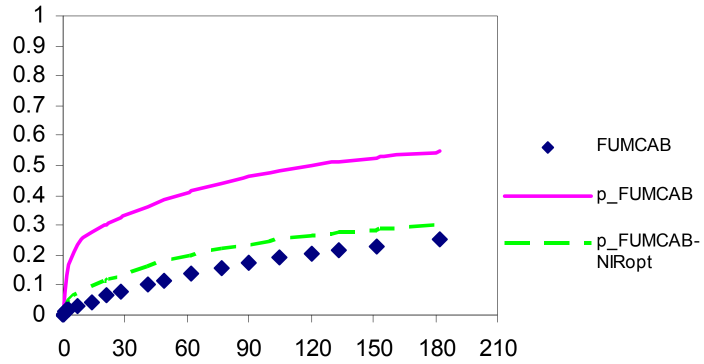
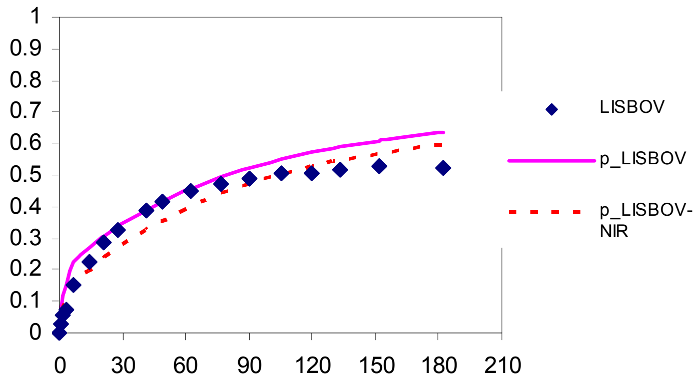
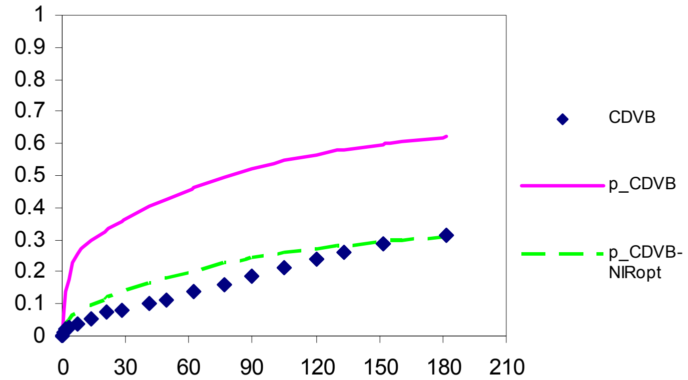
Cmin with TAO & TAO-NIR





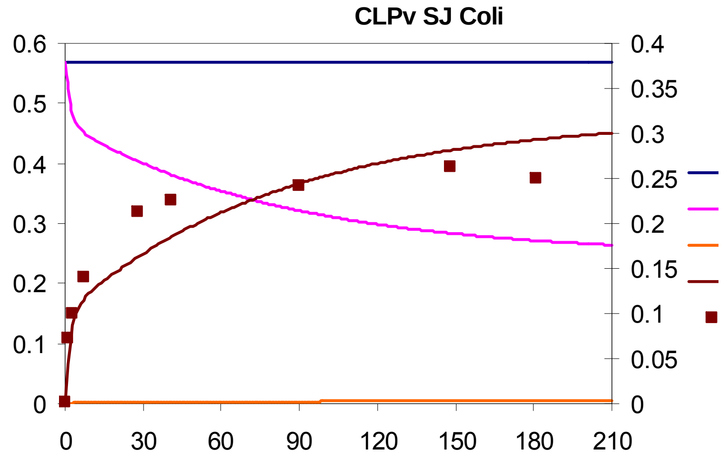


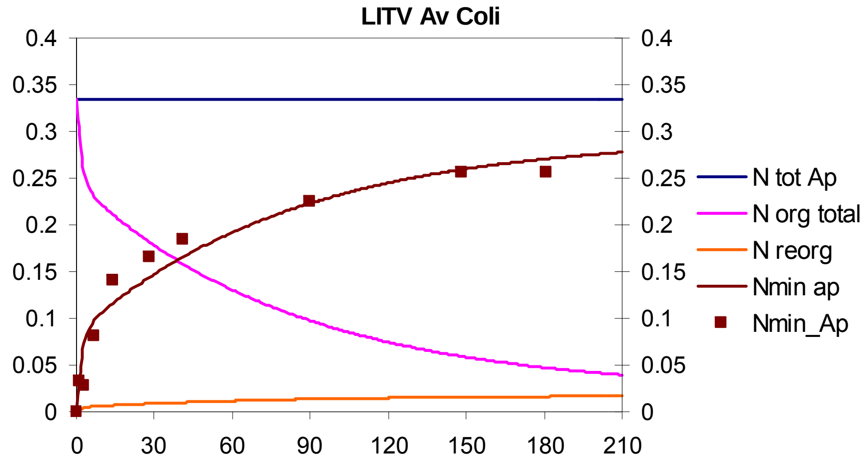


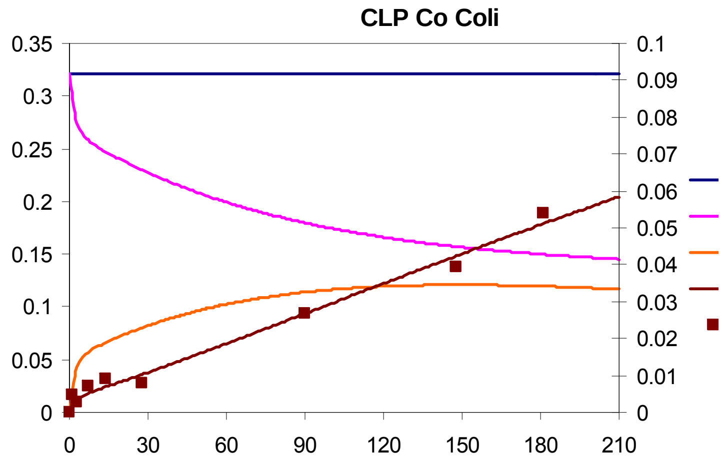
TAO-NIR pred ≈ TAO-bioch pred

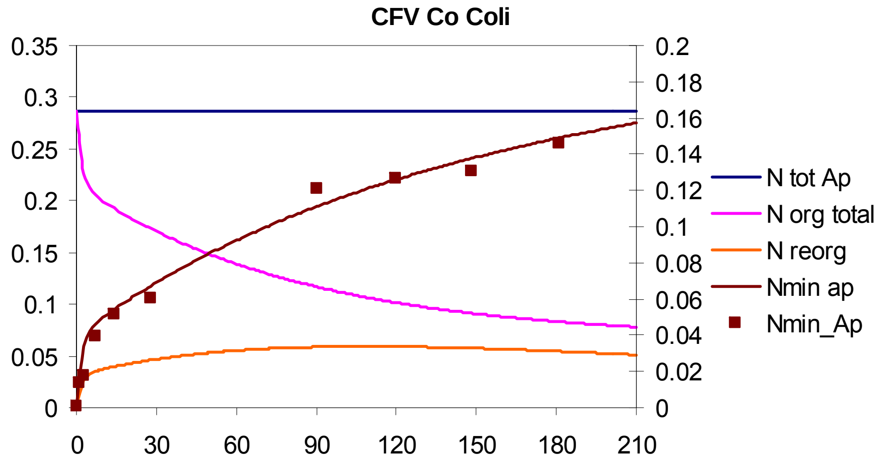
TAO-NIR pred better than TAO-bioch pred

Nmin with TAO









Conclusions

- Both versions of the TAO model can be useful to make OM mineralization predictions :
  - faster and
  - cheaper

  than reference analyses:
    - ~5min *vs* 1 week-6months
    - and ~10€ *vs* 120€-2000~€

- Potential utilizations: selection of the most appropriate usages of OM (agronomic or energy according to a balance benefits/environmental risks)

UR Recycling & Risks

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